URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

12-7A-4
FIRE RESISTIVE STANDARDS FOR
ROOF ASSEMBLIES

STATE FIRE MARSHAL

(a) ***Application.*** *The minimum design, construction and performance standards set forth herein for roof coverings and assemblies are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A*

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(b) Scope. *This standard determines the performance of roof coverings and assemblies when exposed to brands. The burning brand exposure test is intended to determine the degradation modes of roof covering materials or assemblies when exposed to a burning brand on the upper surface. In addition to this standard, all assemblies must comply with other tests in E108 or equivalent standard.*

(c) Referenced documents.

1. ASTM D 4933 Guide for moisture conditioning of wood and wood-based materials
2. ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings
3. California Building Code, Chapter 7A

(d) Definitions*.*

1. Roof Covering. *Roofing material that is directly exposed to the weather.*
2. Roof Assembly. *All materials in the roof system, including roof covering, sheathing, building paper or felt (water resistive barrier), support joists, and any other materials used between the roof joists and roof covering.*

(e) *Equipment.*

1. ***Anemometer****. Device for measuring airflow across the deck.*
2. ***Infrared temperature analyzer*** *(optional). Intended for monitoring the temperature change on the bottom surface of the sheathing material.*

(f) Materials.

1. Material tested must be representative of commercially available products
2. All materials are to be conditioned to equilibrium to 6% EMC conditions prior to testing as specified in ASTM D4933.

(g) Test system preparation

1. Apparatus*. The apparatus shall be constructed as described in Section 4.1, ASTM E-108. The 60-in. (1.5 m) framework spacing specified for the burning brand test shall be used (Figure 1).*
2. Test Deck*. The test deck shall be framed as indicated in Figure 4(a) (Class "A" Roof), referenced in Section 5.1.1, ASTM E-108. Panel joints in solid sheathing shall be configured as indicated in this figure.*

- *i) Sheathing and other materials included in the test deck can be any permitted by the manufacturer of the roof covering.*
- *ii) Framing lumber shall be from species available in a structural light-framing grade. The joists shall be conditioned to 6% EMC as specified in ASTM D 4933.*
- *iii) The roof covering material shall be installed in accordance with manufacturer installation instructions.*
- *iv) Any materials beneath the roof covering that are used to obtain a Class "A" rating must be reported, including labels on the materials that relate to performance or composition.*

v) Panelized barrier materials used to obtain the fire rated assembly must include a joint that is offset from the solid sheathing joint by 4 in. (100 mm). The joint can be either parallel or perpendicular to the airflow direction.

vi) The slope of the prepared test decks shall be as specified in Section 6.7 of ASTM E-108.

***3. Measurement of temperature.** At a minimum, thermocouples shall be placed directly on top of the roof sheathing, and under the felt and other components in the roof assembly, as shown in Figure 2. It is advantageous to use infrared imaging to monitor temperature of the exposed side of the roof sheathing.*

(h) Conduct of Tests

*1. **Number of tests**. Conduct the test on three replicate assemblies.*

***2. Procedure.** Adhere to ASTM E108 "Standard Test Methods for Fire Tests of Roof Coverings" (burning brand test, "A" brand) with regard to the construction and placement of the "A" brand, with the following exceptions:*

i) The air velocity shall be calibrated using the 60-in. (1.5 m) framework spacing.

ii) The ignition procedure of the "A" brands shall be as specified in Section 9.4 of ASTM E 108, except the ignition sequence shall be:

(1) Each 12- x 12-in. (300- x 300-mm) face for 30 s

(2) Each 2.25- x 12-in. (57- x 300-mm) edge for 30 s

iii) Brand position. Place the brand on the roof as specified in E108.

iv) Continue the exposure until flaming or glowing combustion of the roof covering and assembly ceases, burn-through to the underside of the deck occurs, or 90 min elapses.

***3. Observations**. Note physical changes of the roof deck and assembly, including location of flaming and glowing combustion on the exposed upper and lower surfaces, and loss of material (i.e., flaming drops of particles falling from the underside of the deck). It is desirable to capture the entire test for both the upper and lower surfaces of the roof deck with a video recorder to allow review of the details of performance.*

***(i). Report.** The report shall include description of the roof covering material and construction materials and installation details used in the roof assembly and the time of any observation of degradation.*

***(j). Conditions of Acceptance.** Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.*

1. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 90-min observation period.

2. Absence of burn-through to the underside of the roof deck, or development of holes exceeding 1 sq. in. (650 mm^2) resulting from combustion.

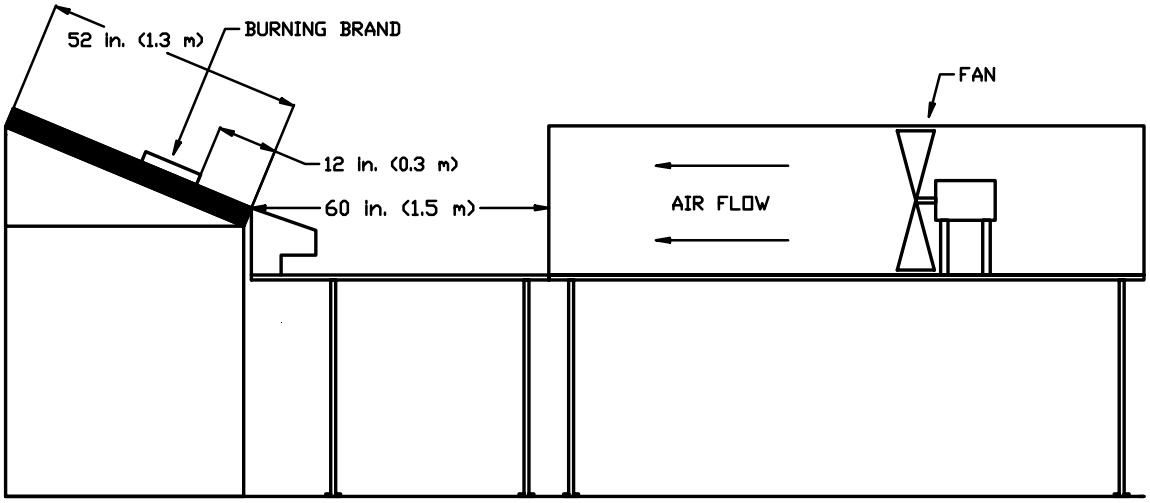

Figure 1. Roof Test Assembly (“A” Brand)

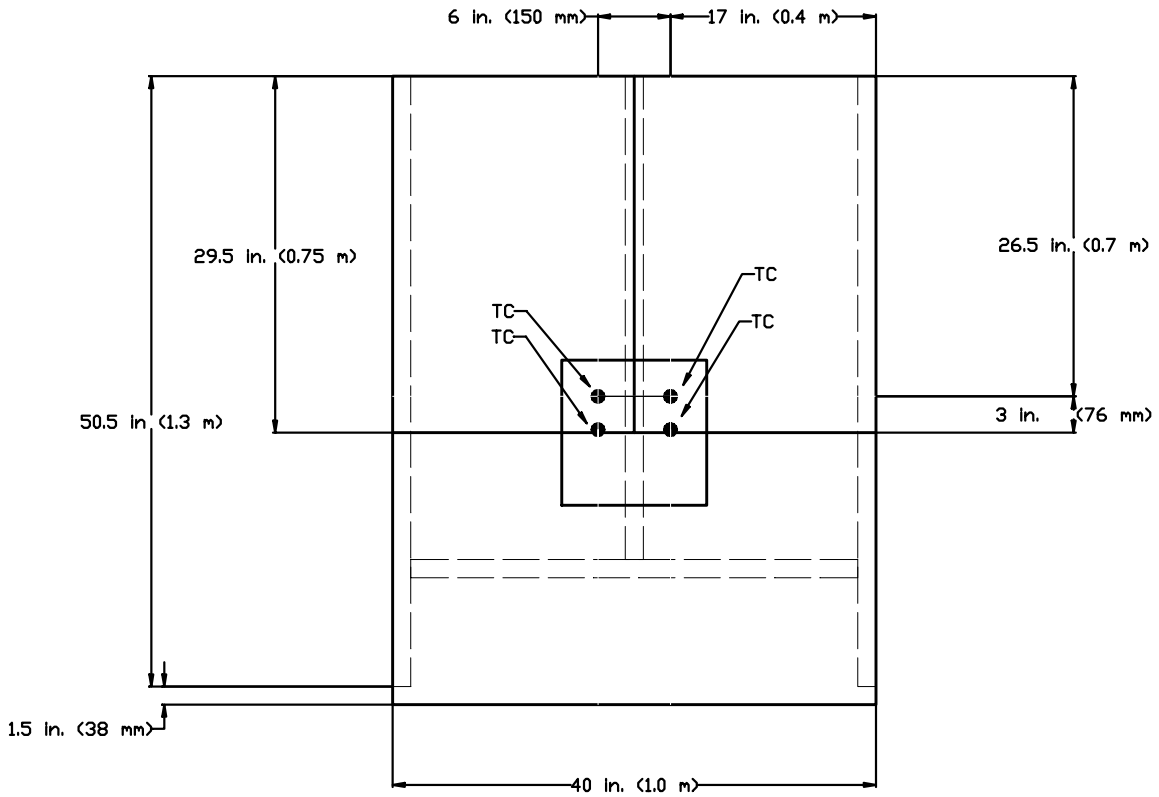

Figure 2. Roof Test Assembly (thermocouple placement)

COMMENTARY: ROOF ASSEMBLIES

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to "certify" materials and/or assemblies, but to provide guidance in the development of the test protocols and for the "conditions of acceptance." Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.
It is well-known that many structures are severely damaged or destroyed in UWI fires because of roofing materials. Roof coverings are already subject to fire regulations that require testing under ASTM E108 or equivalent standards, which represent the only existing performance standards applicable to UWI fire. However, roofs become involved in fire for many reasons other than the roof coverings. For example, the eaves are very vulnerable because of combustible roof edges that are adjacent to rain gutters and the entrapment of burning brands in gutters that contain flammable debris. There are also certain roof coverings and/or designs that permit entry of brands because of unstopped openings or lifting of the coverings from high winds. Complex roof designs often have recesses where combustible debris can accumulate and in which brands can land, and may have combustible vertical surfaces associated with these designs. Most of these latter issues can be addressed by prescriptive measures, or building designs or practices, and it would be very difficult to design meaningful performance tests. Roof coverings have a number of required tests in the current standards that must be passed for ratings. Since the Roof Assembly (SFM-4) is for VHFHZ, the most appropriate rating is "Class A." Class A refers to a 2 kg burning brand, 1 x 1 ft (300 x 300 mm) constructed of a lattice of 36 strips of wood, 0.75 x 0.75 in. (19 x 19 mm) in cross-section.

Roof assembly. E108 is a test method for roof coverings that can be applied to roof assemblies, which include the materials below the covering. The assembly is the same as described in ASTM E108, except that any panelized barrier materials used to obtain the fire rated assembly must include a joint that is offset from the solid sheathing joint by 4 in. (100 mm).

Development of the Test Protocol. The protocol includes a roof assembly as described above and exposed to the “A” brand test. In addition, all assemblies must comply with other tests in ASTM E108 or equivalent standard.

*Air velocity***.** ASTM E108 specifies 12-mph airspeed, however, there have been suggestions that this level of airflow is not representative of UWI "fire weather" conditions that often have winds up to 60 mph. In preliminary tests, it was found that a wind speed of 20 mph was less severe than 12 mph, apparently due to more rapid consumption of the burning brand. Higher velocities simply cause more rapid consumption of the brand and cool the brand area from the higher forced convection. Also, higher airflow can lead to greater losses of fragments of the burning brand as well as dislodging roof coverings. On the other hand, airflow lower than 12 mph supplied sufficient oxygen for vigorous combustion of the brand without the cooling effect. However, at very low airflow, the effect of the brand is more limited because of reduced oxygen.

*Brand size***.** Roof covering ratings are partially based on their performance as affected by the brand size. Since it was reasonable that a larger brand than “A” would be a more rigorous test, “AA” brands were constructed having the same footprint as an “A” brand, but with thicker material to double the mass to 4 kg. When tests were run using an ASTM E108 configuration, the “AA” brands gave virtually the same results as “A” brands, therefore, using the “A” brand was considered a reasonable UWI fire test method.

Tests

In view of the preliminary testing, it initially appeared unnecessary to recommend testing beyond that in ASTM E108. However, it was decided to run tests with different combinations of common materials that are used for class A roof covering certification to determine if the assembly construction (vs covering alone) had any effect on rating. In our testing, it was difficult to determine if and where smoldering combustion occurred or where there was significant temperature build-up during the test. In the E108 test, 8 thermocouples are installed in prescribed places, but this represents a very small sampling of the under-deck area. Since we were using an infrared camera in our wall testing, we attempted to use it for roofs and found that it provided very useful temperature patterns to help define the combustion condition. The roof coverings were built into roof deck assemblies according to manufacturers' specifications. Where fire barrier and sheathing materials were not precisely specified by a manufacturer, we made a variety of test decks with components in common use. The test protocol involved placement of a burning "Class A" brand on the test roof deck and exposing it to a 12 mph wind source. The test was terminated when glowing combustion or smoldering stopped, or when the test deck failed due to flame penetration to the underside of the roof deck.

Materials. Six commercially-available “A”-rated roof coverings (asphalt composition, fire-retardant-treated wood shakes, fiber-cement, concrete tile, aluminum, and fiberglass-reinforced resin) were purchased from retail outlets. CDX plywood and oriented strandboard (OSB), which has largely displaced plywood in roof sheathing, were used as roof decking in matched tests with different roof coverings (Table 1). For selected assemblies, variations were tested with the fire barrier material. All roof decks were constructed according to ASTM E-108, with lapped 30-pound felt under the roof covering. Sheathing was installed with joints, as required in the standard, for both OSB and plywood.

Results. Note that in Table 1, there are several levels of comparison for roof assemblies:

1. Cap sheet 1 vs 2 (both 72 lb, but different manufacturers).

2. CDX plywood vs OSB for the following:
   FRT shakes with DensDeck®
   FRT shakes with Cap sheet 2
   Hardie-Shake wood fiber-cement with no fire barrier
   Owens-Corning resin-glass fiber with no fire barrier

3. OSB/Plywood with covering that passed with no fire barrier for:
   Concrete tile (OSB)
   Asphalt composition (“30-yr”)(OSB)
   Wood fiber-cement (Plywood)
   Resin-glass fiber (Plywood)

4. Fire barriers: Cap sheet vs DensDeck®
   FRT shakes/OSB
   FRT shakes/Plywood

Also note the 70-min flame-through for FRT shake with Plywood and Cap sheet 2. This long period before flame-through was the basis of extending the total test time for the final standard to 90 min.

Comments. The fact that some Class “A” roofing passed with plywood, but failed with OSB, showed that the choice of sheathing material, though not specified by some roofing manufacturers, may be critical to the fire performance of the roof. Also, some manufacturers offer roof coverings as "Class A" rated, with no indication of additional assembly components to achieve this performance. Presumably, any assembly using such a “Class A” covering would pass a "Class A" roof test. Other manufacturers specify additional assembly components and installation details, such as inclusion of a flame barrier of 72-lb capsheet, which enables the roof assembly to pass the E-108 "Class A" fire test. The joint in DensDeck®, which we considered representative of actual roof installation, was where failure occurred when OSB sheathing was used. In the case of the assemblies with 72-lb capsheet (roll roofing), normal installation requires an overlap at the joints, so lack of detail for this type of assembly in E-108 was not an issue.

Although not within the scope of the supporting research, some preliminary tests were made with “C” brands (approx. 9 g in mass) and velocity over 20 mph to reflect a more realistic scenario for the brands that occur during firestorms. This scenario should be included in future tests on valleys and crevices of roofing. An additional issue for future research on roofs is the possible ignition at the edges adjacent to gutters, where accumulated debris could pose a hazard to the roof.

Conditions of acceptance. The major deviation from the “A” brand test in E108 is the requirement of a 90-min period for the test. This is important since smoldering combustion can persist in roof assemblies for a considerable time, and 90 min was judged adequate for assuring that such combustion has terminated.

Table 1. Roof deck construction & fire test results

Product	Covering type	Sheathing[a]	Fire barrier[b]	Result	Test duration[c] (min)
Monier Lifetile "Country Shake"	Concrete tile	OSB	--	Pass	15
James Hardie Bldg. Prod. "Hardislate"	Fiber-cement	CDX	--	Pass	15
Elk Premium Roofing "Prestique I"	Asphalt Composition	OSB	--	Pass	20
Classic Products "Rustic Shingle"	Aluminum	OSB	Cap sheet 2	Pass	23
Owens Corning "Mira Vista Shake"	Resin-glass fiber composite	CDX	--	Pass	23
Cedar-Plus Western Redcedar shakes	FRT wood	CDX	DensDeck®	Pass	58
Cedar-Plus Western Redcedar shakes	FRT wood	CDX	Cap sheet 2	Flame-through	70
Cedar-Plus Western Redcedar shakes	FRT wood	OSB	Cap sheet 1	Flame-through	44
Cedar-Plus Western Redcedar shakes	FRT wood	OSB	DensDeck®	Flame-through	38
Cedar-Plus Western Redcedar shakes	FRT wood	OSB	Cap sheet 2	Flame-through	37
Owens Corning "Mira Vista Shake"	Resin-glass fiber composite	OSB	--	Flame-through	20
James Hardie Bldg. Prod. "Hardislate"	Fiber-cement	OSB	--	Flame-through	16
Eternit "Stonit Continental Slates"	Fiber-cement	OSB	--	Flame-through	14

[a] "OSB" = oriented strandboard; "CDX" = plywood (CDX grade)
[b] Cap sheet 1 & 2 = 72 lb cap sheet (roll roofing) from two different manufacturers;
DensDeck® is a "nonstructural glass mat-faced…gypsum core panel" from Georgia-Pacific Corp.
[c] For those with “pass,” the “test duration” is the time at which all combustion ceased